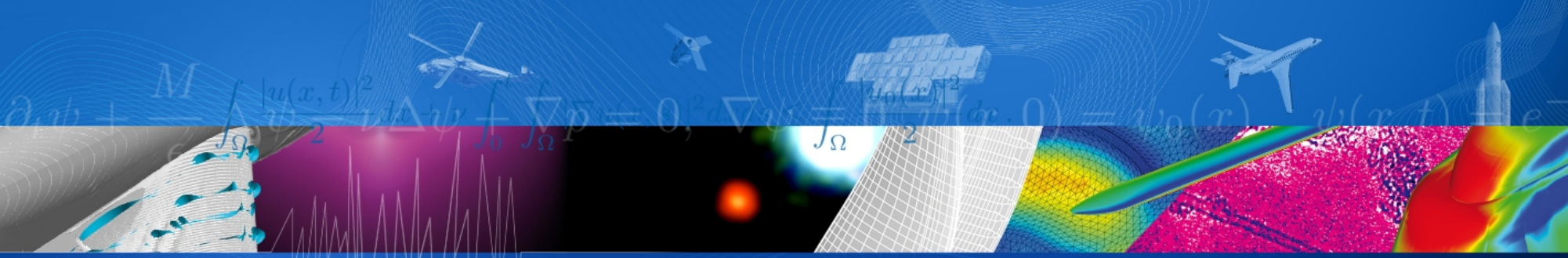

Aerospace Europe CEAS 2017 Conference

A CFD Benchmark of Active Flow Control for Buffet Prevention

Fulvio Sartor, M. Minervino, J. Wild, S. Wallin,
H. Maseland, J. Dandois, V. Soudakov and P. Vrchota

19 October 2017 – Bucharest, Romania

ONERA

THE FRENCH AEROSPACE LAB

Future of civil aviation

- Growth of air traffic worldwide (double every 15 years):
  $\rightarrow$ importance of fuel-burn reduction (environment, economy)
- Aerodynamic performance affects the operating costs of transport:
  $\rightarrow$ need to exploit the full aerodynamic potential of the wing

Future of civil aviation

- Growth of air traffic worldwide (double every 15 years):
  → importance of fuel-burn reduction (environment, economy)
- Aerodynamic performance affects the operating costs of transport:
  → need to exploit the full aerodynamic potential of the wing

Flow control . . . ?

→ Mechanical devices (Gurney flaps) known for a long time
→ Fluidic devices? (fluidic injection, circulation control, . . .)

Purpose of this project and work package:

Explore flow control technologies for future aircraft
. . . here explore the potential of fluidic TED

AFLoNext: Active Flow, Loads & Noise Control on Next Generation Wing

AFLoNext

is a four-year European project with the objective of proving and maturing highly promising flow control technologies for green novel aircraft configurations

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WP5: Multifunctional Trailing Edge Concepts

- **M. Nichols** (BAE Systems)

WP5.1: Aerodynamic Design and Analysis

- **F. Sartor** (ONERA)
- M. Minervino (CIRA)
- J. Wild (DLR)
- S. Wallin (KTH)
- H. Maseland (NLR)
- J. Dandois (ONERA)
- V. Soudakov (TsAGI)
- P. Vrchota (VZLU)

Outline

1 Motivation of the study

2 Numerical benchmarks

3 2D benchmark

4 3D benchmark

5 Conclusions

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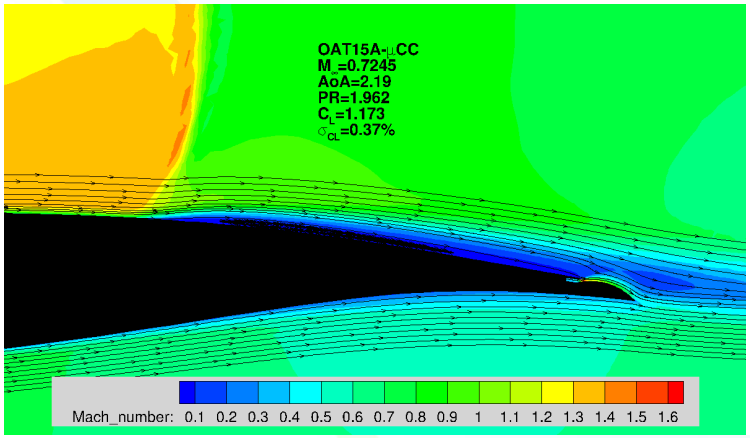
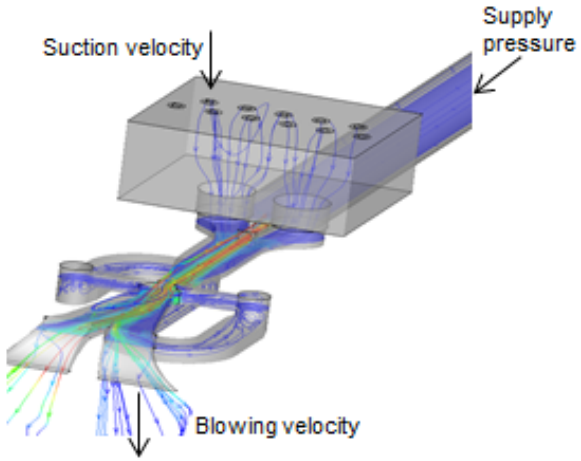
Why a numerical benchmark?

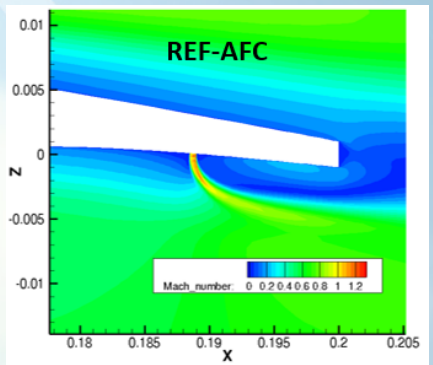
WP5 activities

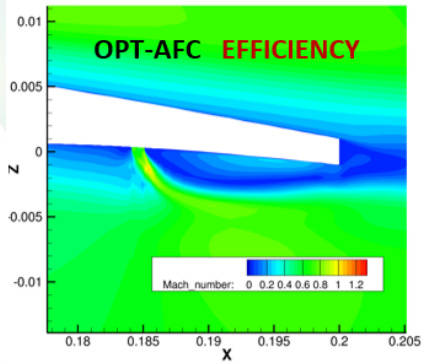
- Predict the performance of different control devices
- Identify the most promising application (buffet control?)
- Perform parametric study to find more efficient configurations
- Optimisation w.r.t. a specific objective (max lift/efficiency?)
- Assist the preparation of wind tunnel experiments in WP5.2

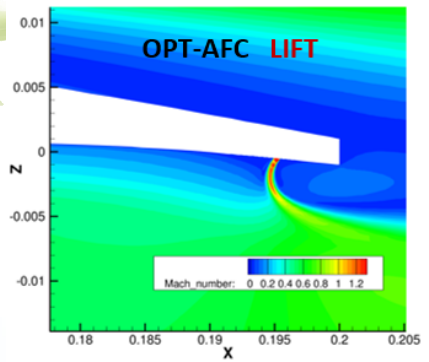
Can we use CFD to investigate flow control?











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Benchmark for code validation

Design of an efficient control device

- needs accurate description the uncontrolled configuration
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- Comparison with available experimental data: AVERT EU project
- Selected test case: transonic flow with/without buffet
- Steady/unsteady pressure and aerodynamic coefficients

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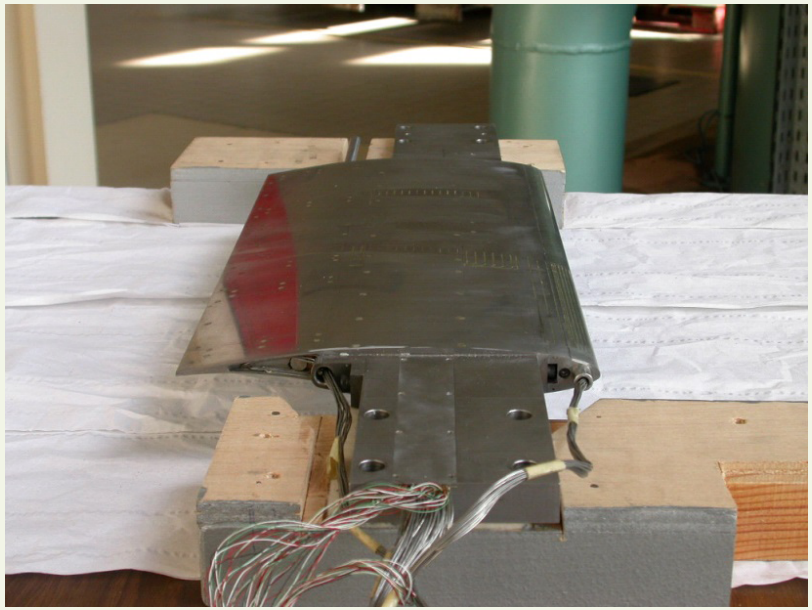
Validation of CFD against experiments

- Two numerical benchmarks have been proposed: 2D/3D
- Code comparison and code validation: U-ZEN (CIRA), elsA (ONERA), TAU (DLR), Edge (KTH, VZLU), NLR and TsAGI

Experimental test cases: AVERT data

2D Test case

2D profile in VZLU



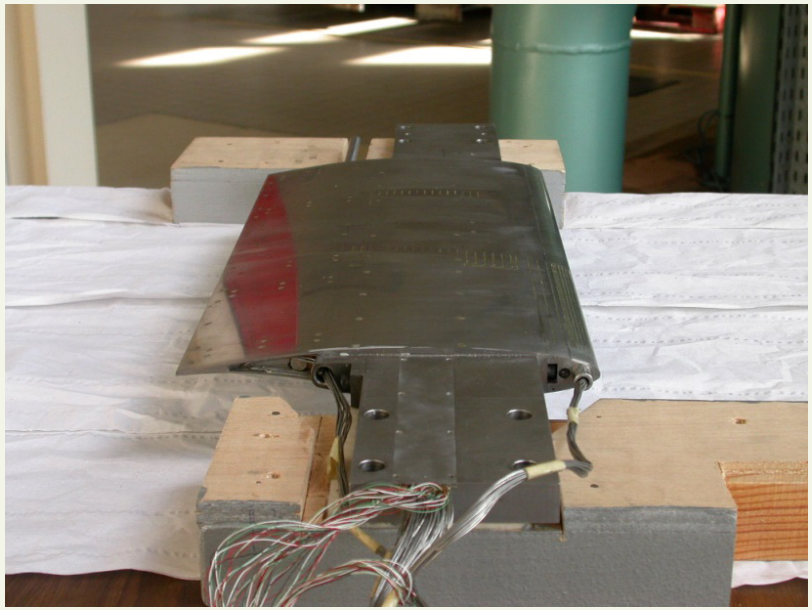
3D Test case

Half wing-body configuration

Experimental test cases: AVERT data

2D Test case

2D profile in VZLU



3D Test case

Half wing-body configuration

Aerodynamic evaluation of reference/controlled configuration

Small angle of attack: steady flow field (stationary SWBLI)
High angle of attack: periodic shock motions (transonic buffet)

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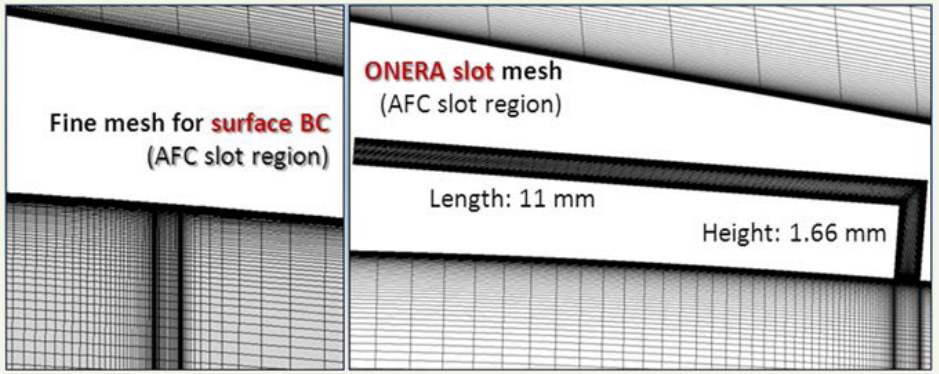
VZLU Wind Tunnel Experiments

Experimental conditions

- ONERA OAT15A profile
- Model equipped with TED
- Mach = 0.73
- Re = 2.6 million

TED modelling



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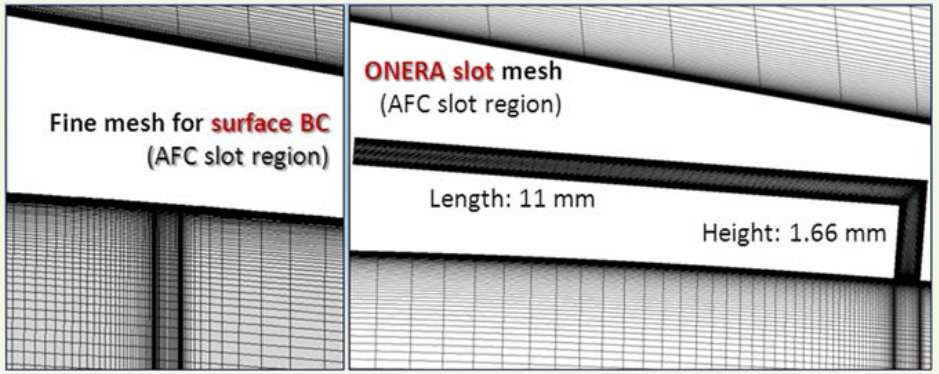
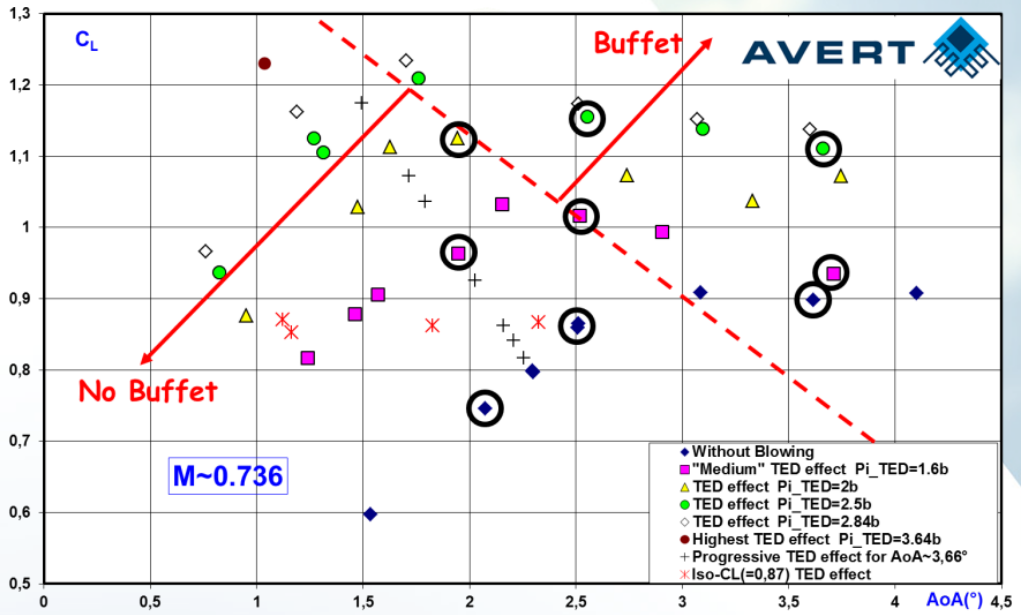


Selected cases

- $\alpha = 1.5°$, $Pi_{TED} = 0.0$
- $\alpha = 3.4°$, $Pi_{TED} = 0.0$
- $\alpha = 2.0°$, $Pi_{TED} = 1.6$
- $\alpha = 3.7°$, $Pi_{TED} = 1.6$



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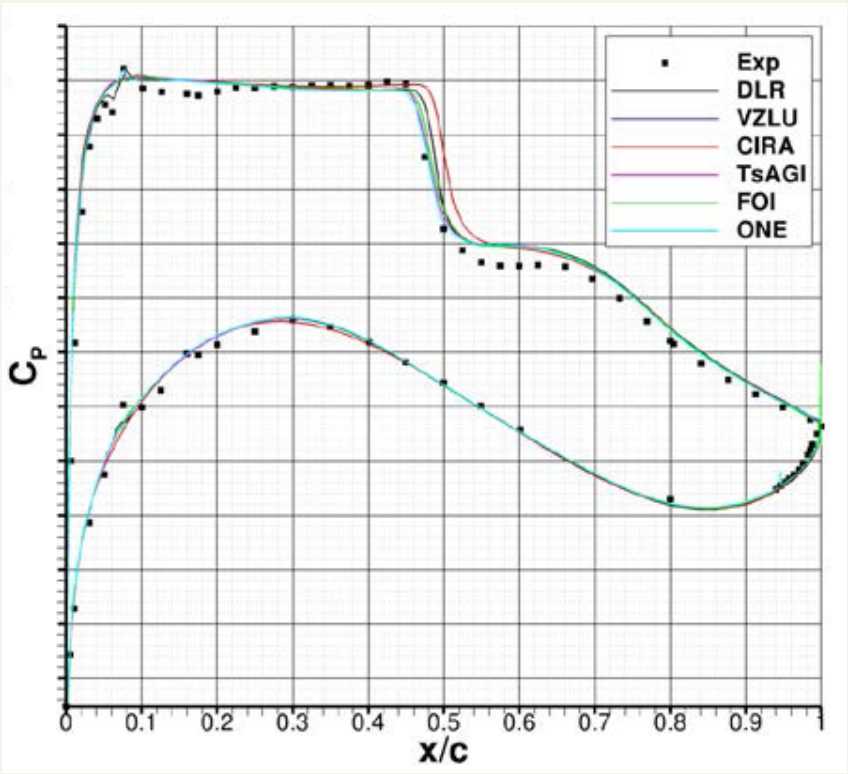
CFD Results, NO control

$\alpha = 1.5°$, no blowing



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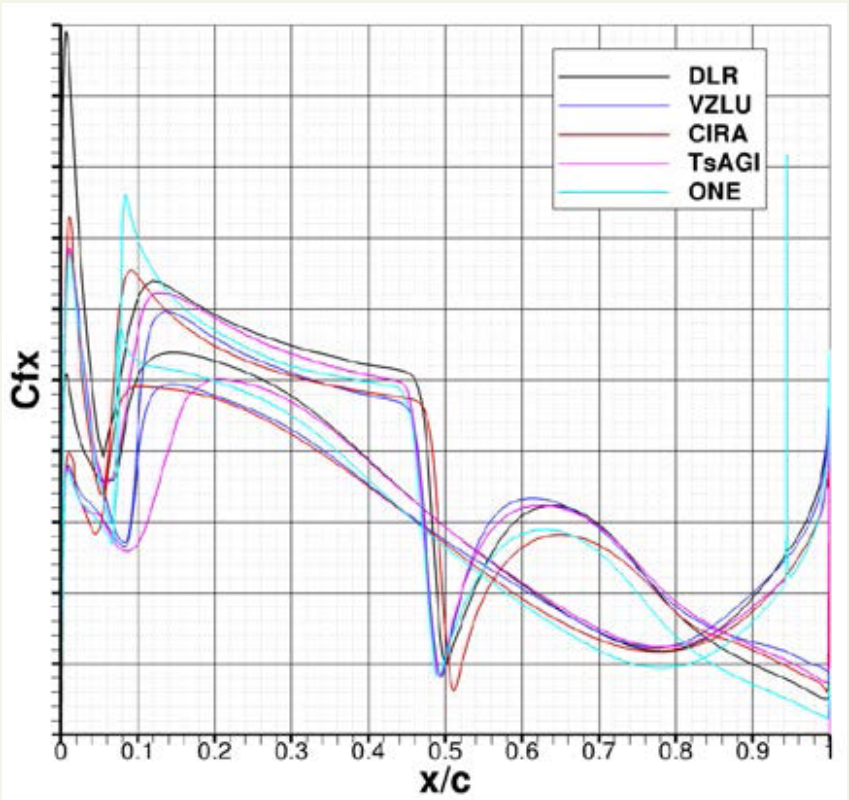
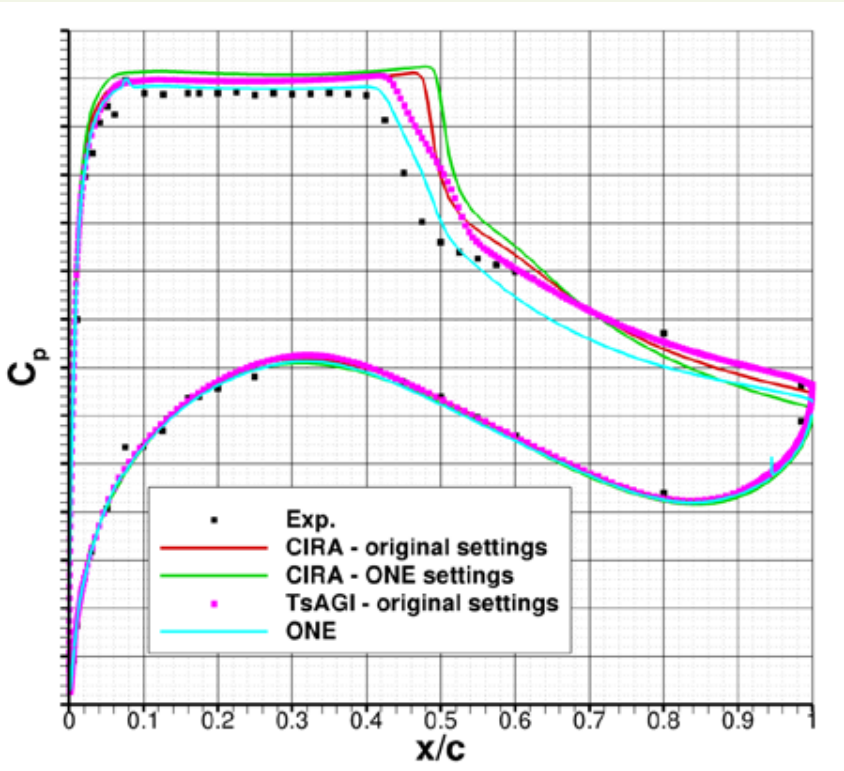


Low angle of attack, without control: **steady solution**

CFD Results, NO control

$\alpha = 3.4°$ without blowing



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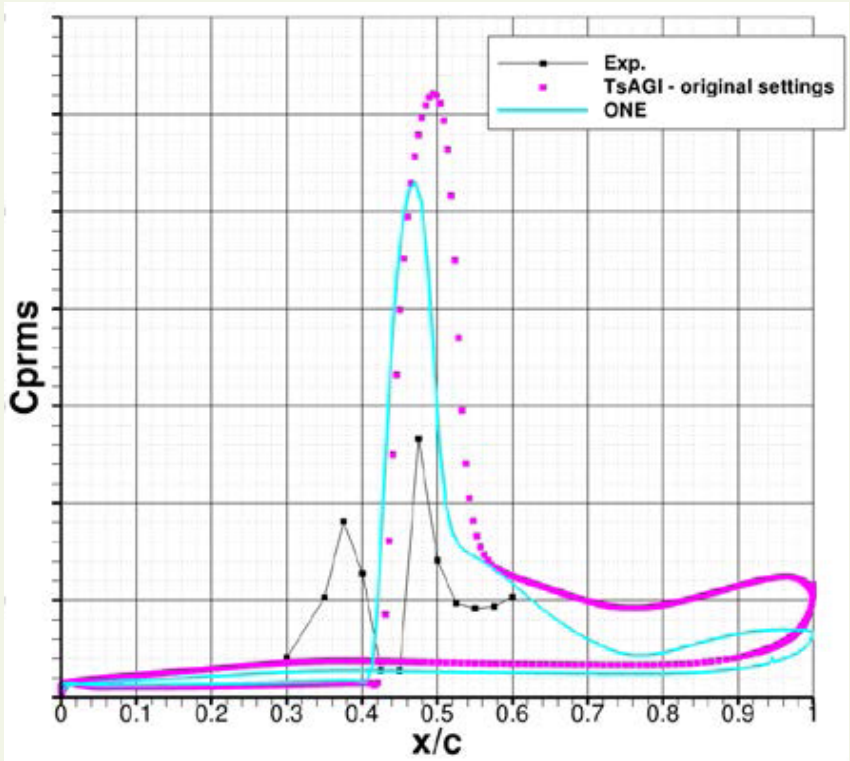
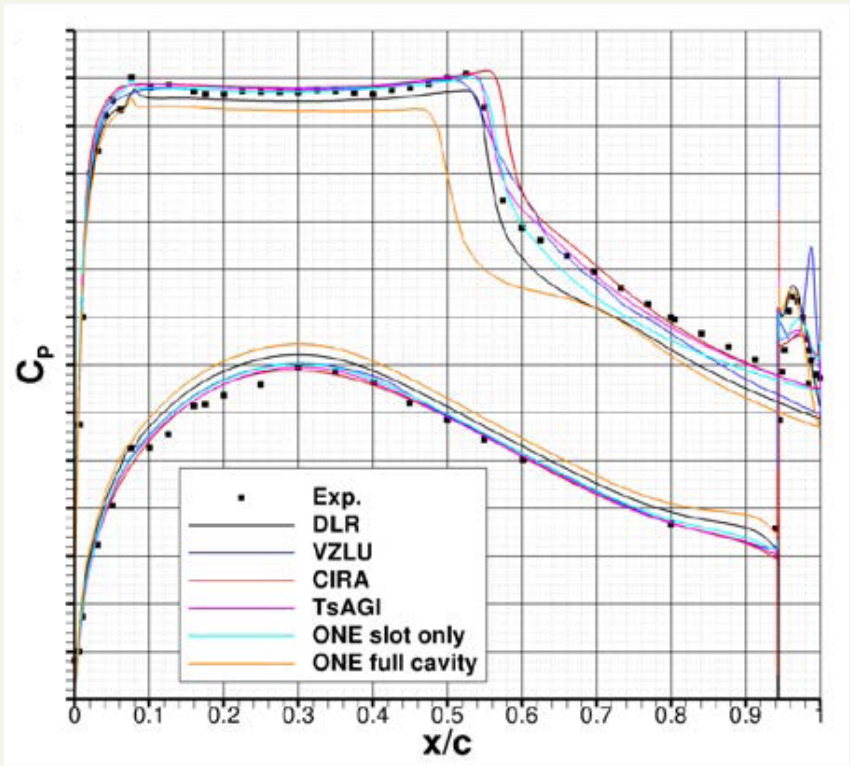


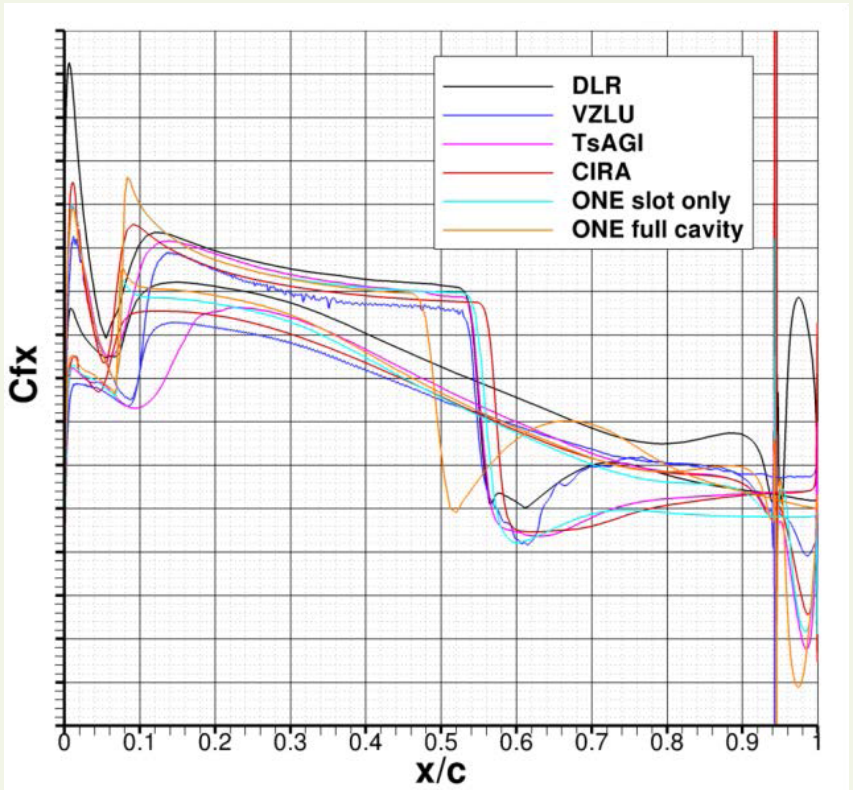
High angle of attack, without control: **unsteady solution**

CFD Results, WITH control

$\alpha = 2.0°$ - $\mathbf{Pi}_{TED} = 1.6$



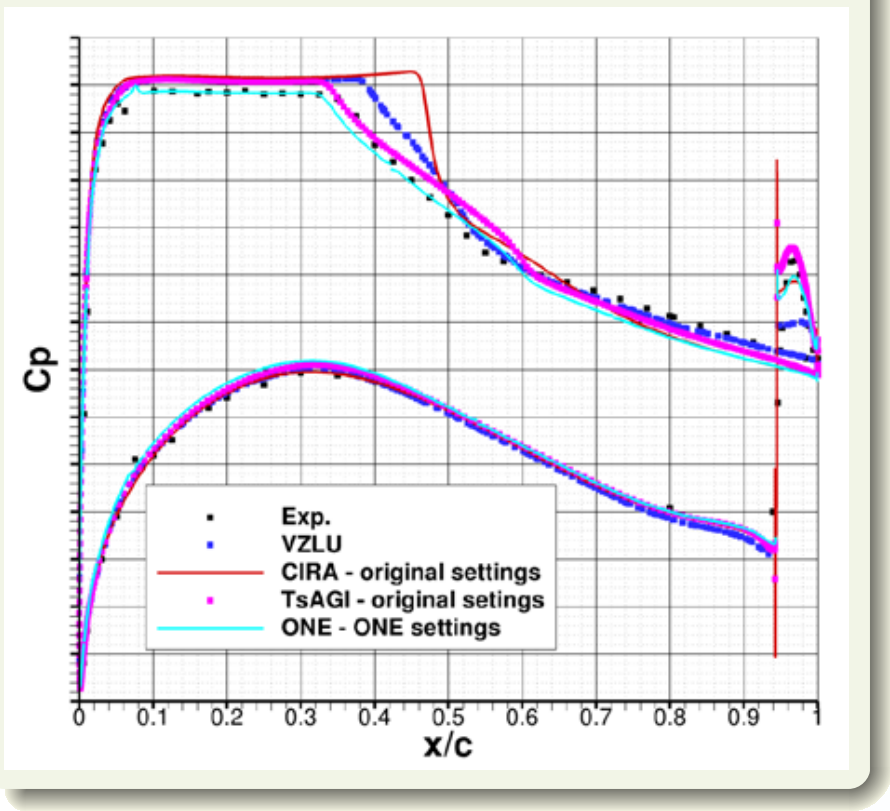
$\alpha = 2.0°$ - $\mathbf{Pi}_{TED} = 1.6$



Low angle of attack, with control: **steady solution**

CFD Results, WITH control

$\alpha = 3.7°$ - $\mathbf{Pi}_{TED} = \mathbf{1.6}$



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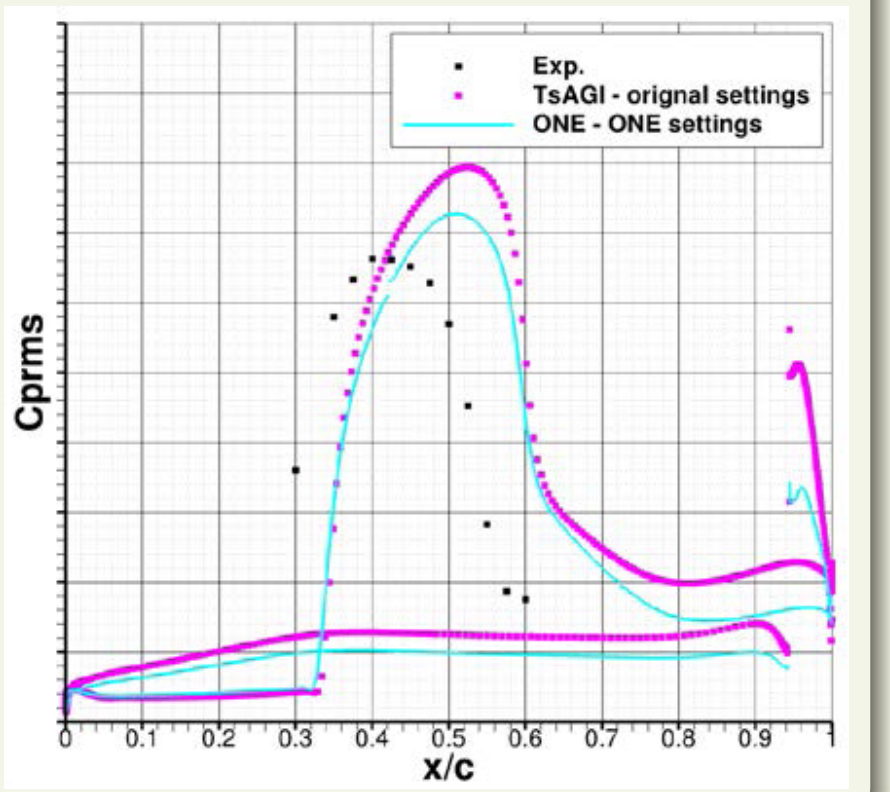

High angle of attack, with control: **unsteady solution**

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ONERA S2Ma Wind Tunnel Experiments

Experimental conditions

- ONERA CAT3D half wing-body configuration
  (wing based on OAT15A aerofoil, peniche + fuselage + wing)
- Continuous blowing through span-wise slot
- Separation control by increasing the rear-loading of the wing

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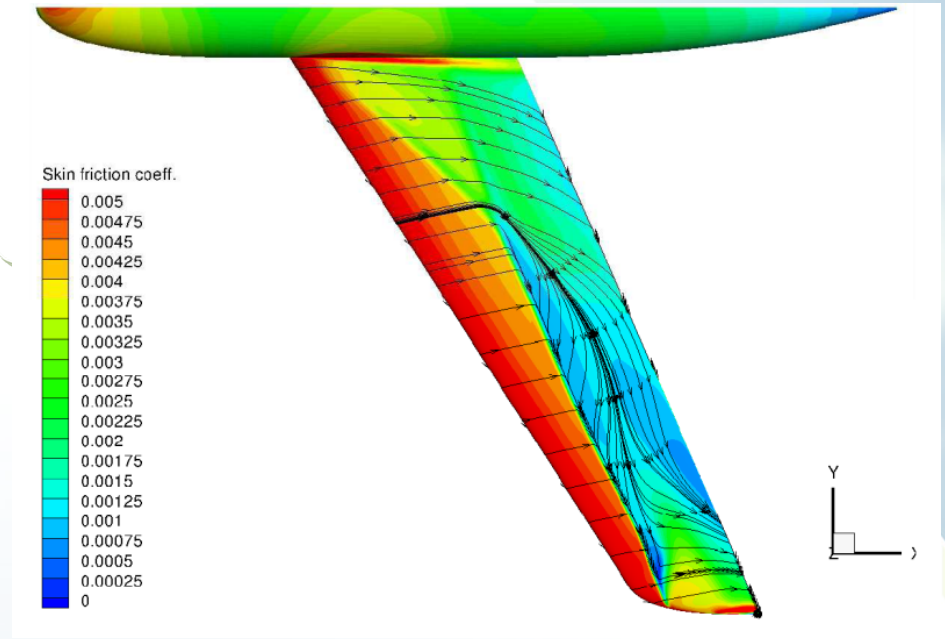
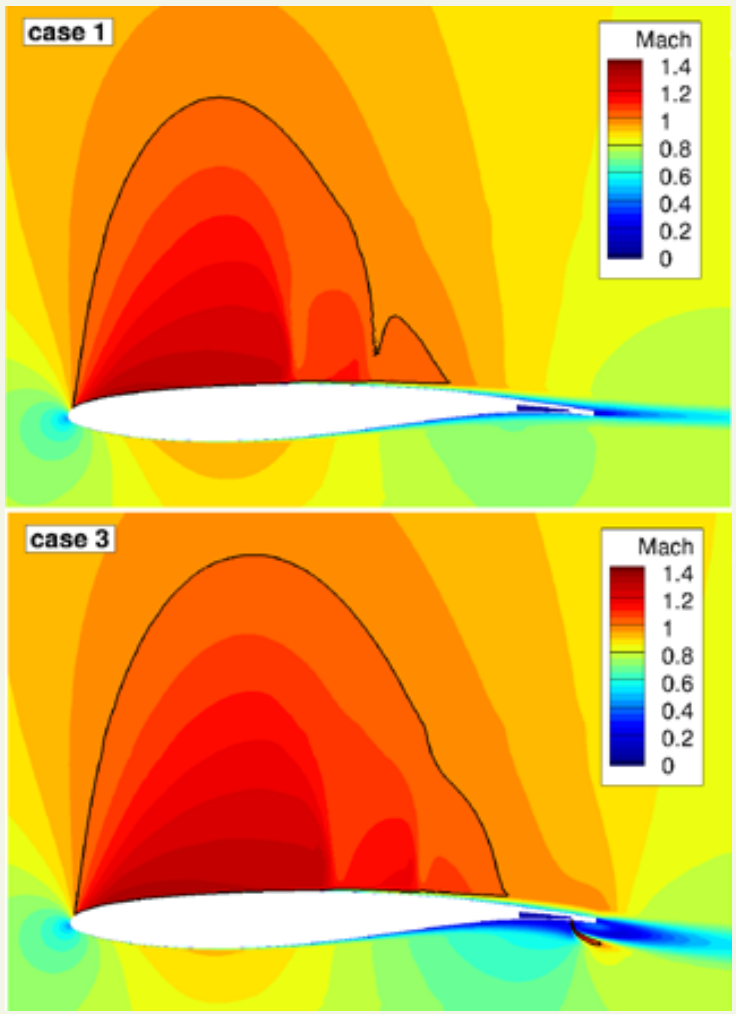
CFD simulations

- Mesh provided by ONERA
- 249 blocks
- 16.86 million points
- description of the whole cavity of the TED



CFD Results

Mach at y/b=55%



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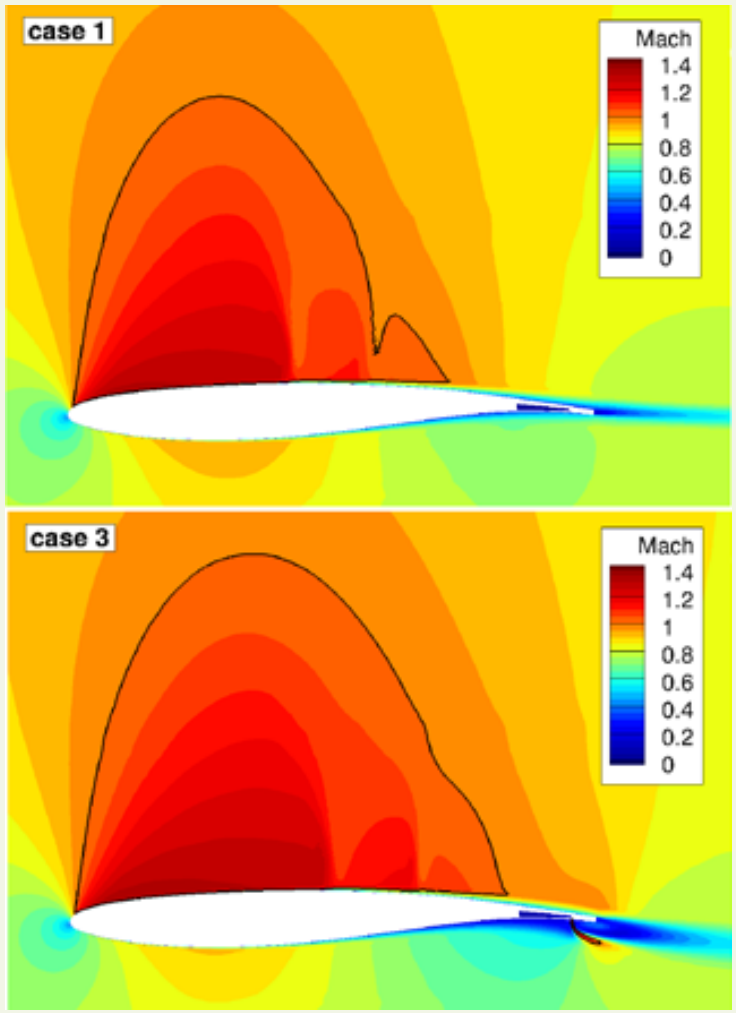
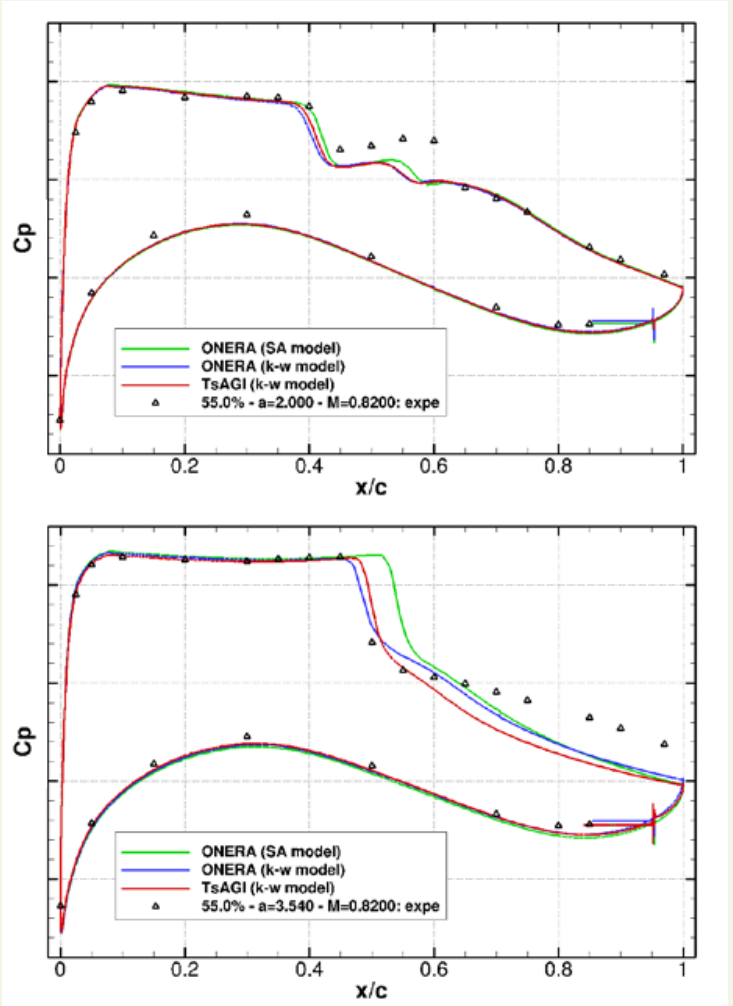


Cp, no flow control



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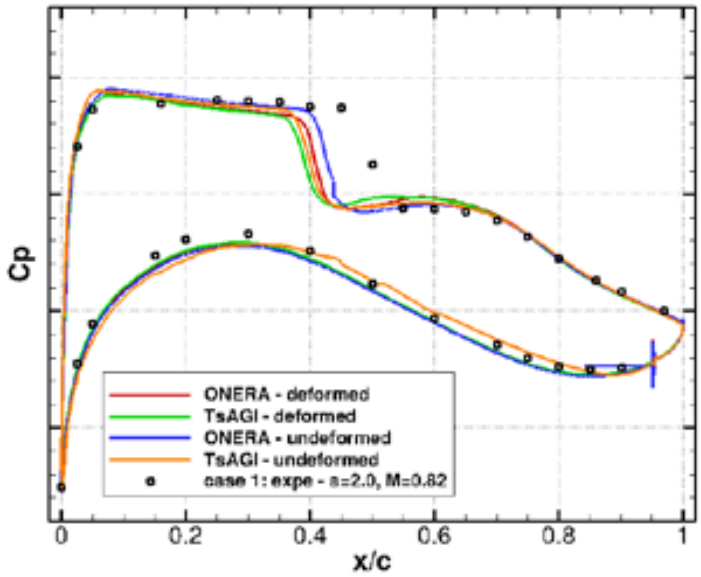
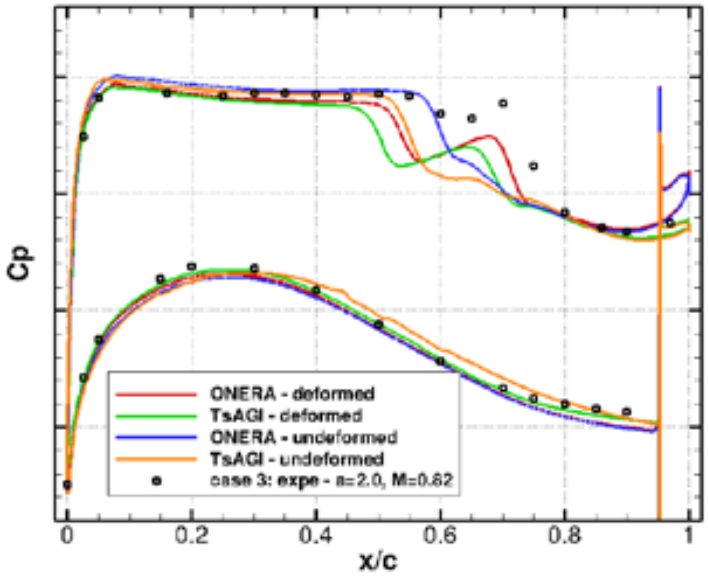

Cp
x/c
0
0.2
0.4
0.6
0.8
1
ONERA - deformed
TsAGI - deformed
ONERA - undeformed
TsAGI - undeformed
case 1: expe - a=2.0, M=0.82


Cp
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0
0.2
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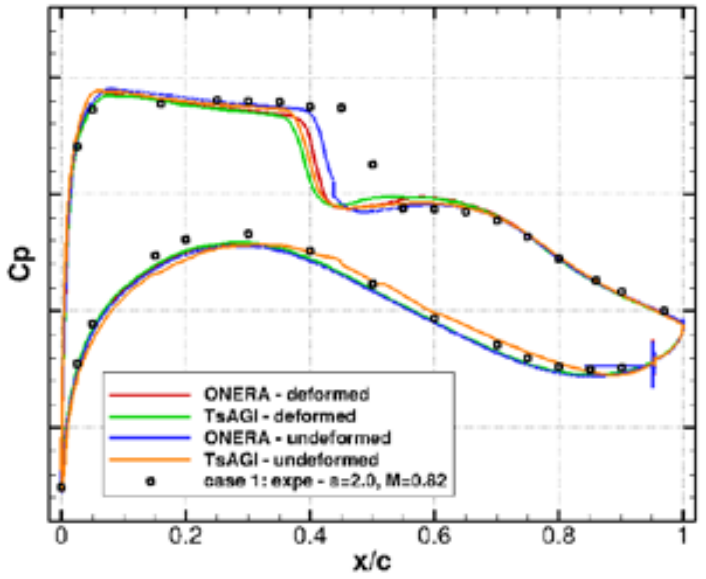
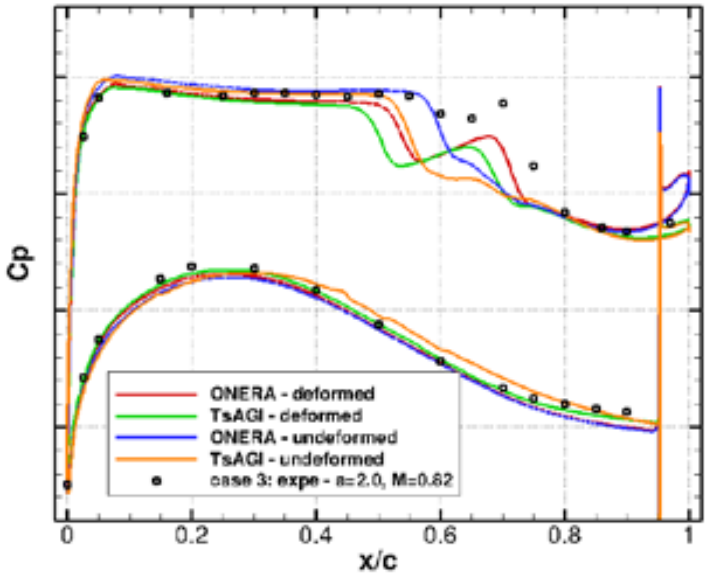
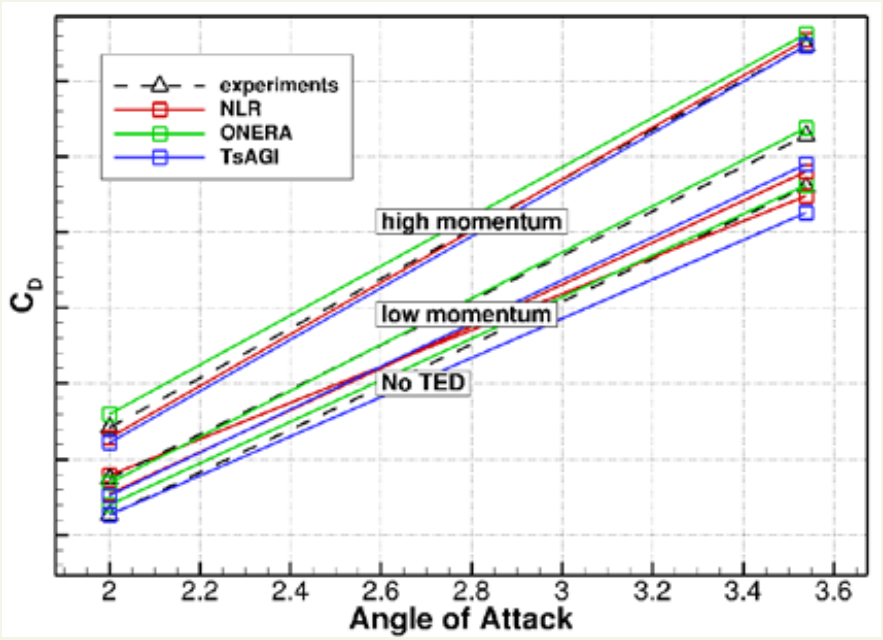
case 3: expe - a=2.0, M=0.82

CFD Results





Drag polars



- reduction of drag at fixed C_L
- enhancement of the aerodynamic efficiency
- multi-functional use of TED

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- Indications of best position for maximising lift or lift-to-drag ratio
- Larger/smaller slot distant/close to TE for max efficiency/lift

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Thanks

- Funding from the EC Seventh Framework Programme FP7/2007-2013 (grant agreement $n°$604013)
- Colleagues from WP5.1
- You for your attention!